NRL Modeling in Support of ASAP MURI 2006 Experiment in the Monterey Bay

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LONG-TERM GOALS

The long-term objective is to contribute to the development of the components of limited area, open boundary, and coastal nowcast/forecast systems that will resolve the time and length scales of the relevant physical-bio-optical dynamics in shallow coastal environments.

OBJECTIVES

In collaboration with Multi-disciplinary University Research Initiative (MURI) "Adaptive Sampling and Prediction (ASAP)" project scientists:

conduct the analysis of the MB2006 experiment observations and model results, and compared them with post-experiment analysis of other two experiments AOSN II (2003) and AOSN I(2000).

Estimate the heat budget of the three dimensional upwelling center and evaluate relative contribution of different terms to the heat budget.

Evaluated the impact of glider data assimilation and assimilation of other observational assets (data denial experiments) on surface and subsurface properties of the NCOM predictions. A number of error metrics were used for skill assessment and error analysis of the modeling system predictions. Results from the data denial experiments are interpreted utilizing adjoint sensitivities maps.

APPROACH

To accommodate the wide range of horizontal scales of physical and biological oceanic processes, NRL provides real-time nowcast and forecast products from the hierarchy of different resolution NCOM (Navy Coastal Ocean Model) based data assimilating models: global, regional California Current System (NCOM CCS), and two high resolution models around the Monterey Bay area (NCOM ICON and NCOM frsICON models, see http://www7320.nrlssc.navy.mil/ccsnrt/).
This system provides large-scale, basin-scale, and small-scale views on physical conditions and circulation in the Monterey Bay. Predictions from these different resolution models were used during

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July –August of 2006 experiment in the Monterey Bay area. The NCOM model (Martin, 2000) is a parallel version model capable of running reliably on many computer platforms. The model includes capabilities for nesting, as well as the use of a variety of vertical coordinate systems such as hybrid (sigma-z) or sigma. Observations from gliders, AUVs, aircraft surveys and ship cruises are assimilated by using the NCODA data assimilation system.

Research is being performed in collaboration with the interdisciplinary research team involved in AOSN experiments in the Monterey Bay (scientists are from MBARI, WHOI, Harvard, Princeton, Caltech, NPS, JPL, and NRL Monterey).

WORK COMPLETED

In collaboration with the MURI ASAP researchers we conducted the analysis of the MB2006 experiment observations and model results, and compared them with post-experiment analysis of other two experiments AOSN II (2003) and AOSN I(2000).

Evaluated COAMPS predictions of momentum, short and long wave radiation fluxes and compared them with the available mooring observations; estimated the heat budget of the three dimensional upwelling center and evaluated the relative contributions of different terms to the heat budget.

Evaluated the impact of different observational assets (data denial experiments) on predictions of surface and subsurface properties of the model.

Four papers with our participation were submitted to the AOSN II special issue.

RESULTS

The impact of glider data assimilation on the NCOM ICON model predictions was evaluated during the AOSN II (August –September of 2003) and MB2006 (August-September of 2006) experiments. For AOSN II, the impact of glider data assimilation on the model subsurface temperature and salinity predictions at mooring location M2 is shown on Figure 1. Observations (panel (A) on Figure 1) show sharp changes in the thermocline and halocline depths during transitions from upwelling to relaxation and visa versa. There is a strong deepening of thermocline during the upwelling events, and a shallowing of the thermocline during the brief relaxation events. The non-assimilative run shows these transitions in subsurface temperature; however, changes are not as defined as in observations (Figures 1, (B)). For salinity, the non-assimilating run significantly differs from the observations. However, the glider data assimilating run is able to show comparable results with observations in the deepening (shallowing) of thermocline as well as halocline depths during upwelling (relaxation) events in the Monterey Bay area (Figure1, (C)). For MB2006 experiment, the impact of glider data assimilation on the model subsurface temperature and salinity predictions at the mooring location M1 is shown on Figure 2. In contrast to the AOSN II results the assimilation of glider data has minimal impact on model predictions of subsurface properties at the mooring location during MB2006. The results for non-assimilative and assimilative runs are similar, and deviate from the observed subsurface structure at the mooring M1 (Figure 2). Note, that during AOSN II experiment, glider tracks covered the area of the model evaluation (moorings M1 and M2), while during MB 2006 experiment, glider tracks were to the north of the mooring locations. Differences in impacts of glider data assimilation during AOSN II and MB2006 experiments can be explained with adjoint sensitivities maps presented on Figure 3. They show sensitivity of the tracer forecasts (at locations of the mooring M1) to the initial conditions around

30 hours prior to the forecast. Sensitivities maps are shown for upwelling and relaxation events during MB2006. High areas of sensitivity (red areas) are where initial conditions are most influential on the forecast at the mooring location and where sampling is most important. Based on Figure 3, it is clear that glider tracks during MB2006 did not sample the water masses critical for improvement of the forecast at the mooring location. This is why during MB2006; there is a minimal impact of glider data assimilation on model predictions at moorings locations.

IMPACT/APPLICATIONS

In situations where it is difficult to obtain extensive data sets to validate numerical models and techniques in areas of Navy strategic importance, our development and testing of the components of limited area, open boundary, coastal nowcast/forecast systems, together with extensive observational programs in and around the Monterey Bay Area, allow continued development of novel techniques for data assimilation and adaptive sampling.

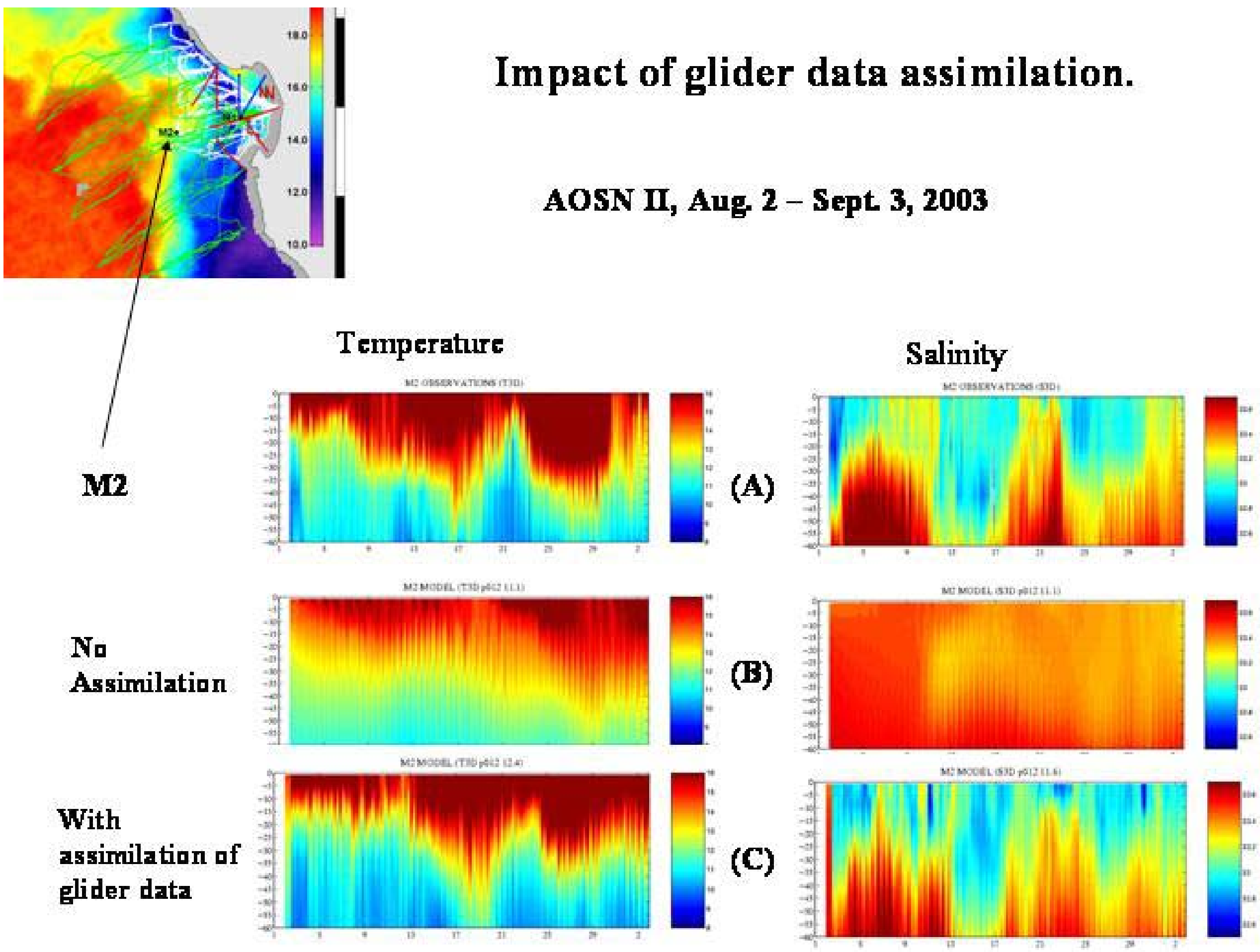

Figure 1. AOSN II experiment. Comparisons of observed and model predicted subsurface temperature and salinity at mooring M2: (A) observed; (B) non-assimilative run; (C) the run with assimilation of only glider data.

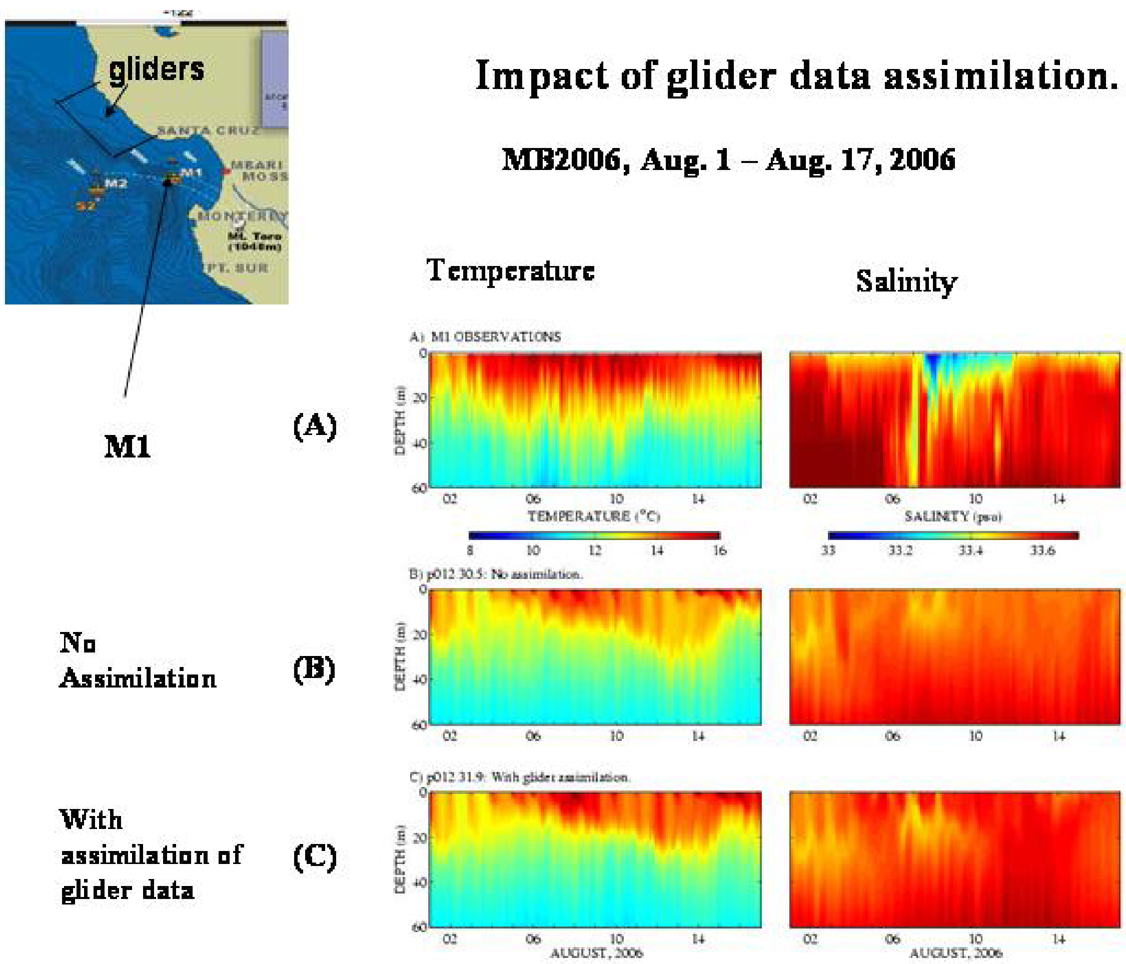

Figure 2. MB2006 experiment. Comparisons of observed and model predicted subsurface temperature and salinity at mooring M1: (A) observed; (B) non-assimilative run; (C) the run with assimilation of only glider data.

TRANSITIONS

Model predictions were provided to the Collaborative Ocean Observatory Portal of the MB2006 experiment.

RELATED PROJECTS

DOD/ONR MURI ASAP (PIs: N. Leonard and S. Ramp)
Coordination with a joint effort by the Princeton, NPS, Harvard, MIT, MBARI, WHOI, NPS, etc. in MB2006 post-experiment analysis.

NRL, "Coupled Bio-Optical and Physical Processes (CoBiOPP)" (PI: J. Kindle)
I. Shulman is actively involved in bio-physical modeling of West Coast Ecosystem in the framework of this project.
NRL, "Air-Ocean Coupled Processes in the Coastal Zone" (PI: J. Kindle)
I. Shulman conducts research related to the coupling oceanic and atmospheric models.

NRL, “Variational Data assimilation for Ocean Prediction” (PI: H. Ngodock, Co-PI: I. Shulman)
Development of advanced variational data assimilation techniques.
NPS, "Center for Integrated Marine Technologies"
(PIs: L. Rosenfeld and J. Paduan)
Development of integrated observational-modeling system in the Monterey Bay area.

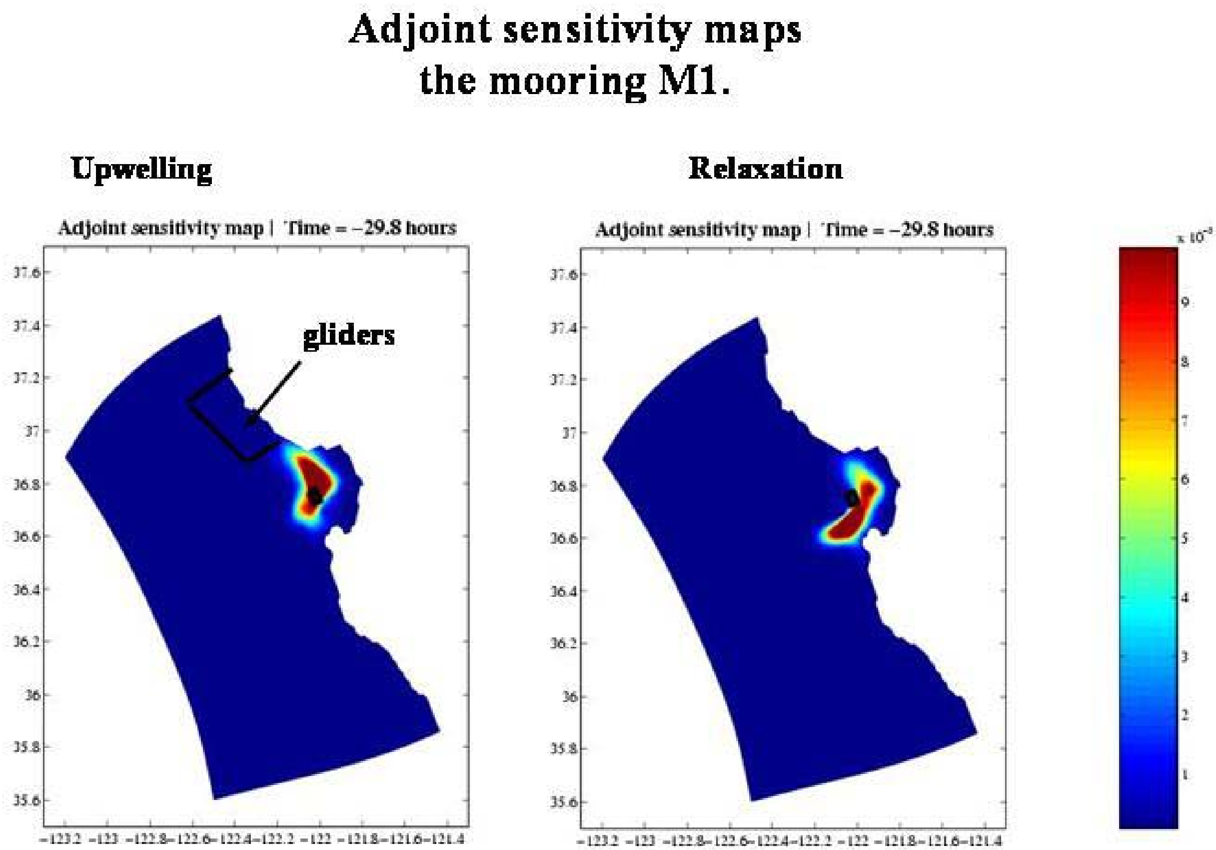

Figure 3. Adjoint sensitivities maps at mooring M1. Sensitivities maps are shown for upwelling (left) and relaxation (right) events during MB2006.

PUBLICATIONS

Igor Shulman, John Kindle, Paul Martin, Sergio deRada, Jim Doyle, Brad Penta, Stephanie Anderson, Fei Chai, Francisco Chavez, Jeff Paduan and Steve Ramp, 2007. Modeling of upwelling/relaxation events in the coastal ocean, *Journal of Geophysical Research,* V. 112, C06023, doi:10.1029/2006JC003496 .

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